Ghosh, G. (2009). Evaluating prospects of reintroducing cheetahs (Acionony x jubatus) in Kuno Wildlife Sanctuary. Tigerpaper 36(2): 24-28.

Keywords: 4IN/Acinonyx jubatus/cheetah/evaluation/Kuno Wildlife Sanctuary/PHVA/population viability/reintroduction/survey

Abstract: India's conservation outlook and efforts would be better served if the cheetah was reintroduced into India, mainly because of the amount of potential revenue that such an undertaking would generate, through ecotourism. This paper evaluates the deciduous thorn forest encompassing Kuno Wildlife Sanctuary as a possible reintroduction site. This area was selected because it has a large area, the density of human habitations is low, and it was a part of the historical range of the cheetah. The study area also does not have a high density population of large carnivores. The study area was analyzed through a population habitat viability analysis of primary data collected on Kuno by line transect surveys and demographic parameters of the cheetah, obtained from a review of literature of various studies on the cheetah.

EVALUATING PROSPECTS OF REINTRODUCING CHEETAHS (*Acinonyx jubatus*) IN KUNO WILDLIFE SANCTUARY

by Ganesh Ghosh

Introduction

At the time of Christ, the cheetah was found throughout Africa and southwestern Asia (including India). Currently, cheetahs are found in about 25 African countries and Iran (5). The last physical evidence of the Asiatic Cheetah in India were the three shot (with two bullets) by the Maharajah of Surguja in 1947 in eastern Madhya Pradesh, in central India (6). In the Indian sub-continent, cheetahs were present from Pakistan (including the Indus river basin) to the states of Bihar and Orissa in India and to the state of Tamil Nadu in south India (Divyabhanusinh, 1995). The cheetah was continuously removed from the wild for the sport of coursing antelope for at least a millennium if not more. Undoubtedly, this had a considerable effect on its survival in its natural habitat. Particularly, the capture of females would have made the survival of cubs in the wild impossible. Additionally, in its final phase the animal came to be hunted relentlessly by the British as well as by Indians, which snuffed out the last remnants of its population.

The cheetah's mode of hunting, which is running down its prey in a short monumental burst of speed, is highly specialized. For this performance it required open grasslands and scrublands. With a growing human population and the attendant growth in cattle and other livestock, such ecosystems were obviously the first to come under pressure in the subcontinent.

With the loss of their habitat and hence prey, cheetahs started preying on livestock. This caused conflicts with humans and more cheetahs were killed. Moreover, cheetahs could not rear their young with continuous human and livestock interference (Divyabhanusinh, 1995).

India's conservation outlook and efforts would be better served if the cheetah was reintroduced into India, mainly because of the amount of potential revenue that such an undertaking would generate, through ecotourism. This paper evaluates the deciduous thorn forest encompassing Kuno Wildlife Sanctuary as a possible reintroduction site. This area was selected because it has a large area, the density of human habitations is low, and it was a part of the historical range of the cheetah (Qureshi, 2006; Divyabhanusinh, 1995). The study area also does not have a high density population of large carnivores (Jhala *et al*., 2007, Jhala, pers. comm.). The study area was analyzed through a population habitat viability analysis of primary data collected on Kuno by line transect surveys and demographic parameters of the cheetah, obtained from a review of literature of various studies on the cheetah.

Study area

The study area was the grassland ecosystem which encompasses the Kuno Wildlife Sanctuary. Kuno Wildlife Sanctuary (or Palpur-Kuno Wildlife Sanctuary) is located between latitudes 25°30'-25°53'E & longitudes 77°07'-77°26'N. It lies in the Sheopur district of northwestern Madhya Pradesh, in central India (1). The total area of the ecosystem is 3,000 km^2 (Qureshi *et al*., 2006). The climatic conditions of Kuno Palpur Sanctuary are moderate, but slightly arid. The average elevation of the sanctuary from mean sea level ranges from 238 m to 498 m. The average annual rainfall is 760 mm. There are three distinct seasons with no real autumn. The forests found in Kuno Wildlife Sanctuary are classified into the following types: northern tropical dry mixed deciduous forest, *Angeissus pendula* forest and *Boswellia* forest (Champion & Seth, 1968; Choudhary, 2001). The

general physiography of the terrain is hilly. It comes under the Vindhya series. The sanctuary falls in the semi-arid zone and has a terrain typical of the Central Indian highlands, interspersed with woodlands and meadows. The soil is sandy and sandy-loam, showing a spatial variation in depth. The Kuno River, a tributary of Chambal River, vertically bisects the sanctuary from north to south. It occupies an area of 5.90 km^2 in the sanctuary (2). The species of prey available for cheetahs to catch are nilgai and cattle calves, chinkara, chital, langur, peafowl and wild boar.

Methods

The prey densities for the grassland ecosystem which encompasses the Kuno were estimated using line transect sampling (Burnham, 1980), and then analyzed by the software DISTANCE (Laake, 1992) in order to determine cheetah prey density. A population habitat viability analysis (Lacy, 1993/ 1994; Seal, 1993) using the software Vortex (Lacy, 2000) was done in order to determine the probability of a successful cheetah reintroduction. Various scenarios were simulated in Vortex by changing certain parameters, while keeping others constant.

Line transect sampling

The author sampled 41.9 km by vehicle transect to estimate cheetah prey abundance in Kuno. The data was recorded along with the group size and structure on the perpendicular distance on all species sighted with the help of a laser range finder. The data was recorded in prescribed formatted data sheets and analyzed using DISTANCE software (Laake, 1992).

Population habitat viability analysis

A population habitat viability analysis simulation was run for Kuno and the inputs used for it were obtained from primary data collected in Kuno by line transect surveys; demographic parameters of cheetahs were obtained from a review of literature of various studies by Caro (1994) and Eaton (1977).

One of the parameters in the PHVA model was carrying capacity, using the following parameters:

- The cropping rate of wild prey by cheetahs is conservatively considered as 5%, as other large carnivore densities at both sites were low (Karanth, 1987).
- A cheetah family will hunt once every 3 days, therefore making 121 kills a year.
- A cheetah family consists of a mother and three cubs on average.

The carrying capacity of the Kuno ecosystem was calculated as follows:

Kuno Wildlife Division
(5% of (D * Area)/121)*4
D = Density of cheetah prey
Density = 32 animals
Area = 1,280 km^2 (Choudhary, 2001)

Surrounding areas
The density is expected to be one-fourth that of Kuno WLS
(5% of (0.25*D * Area)/121)*4
Density = 8 animals
Area = 1720 km^2

Total carrying capacity of the Kuno ecosystem = 91 animals.

The simulations were modeled for 100 years with 1,000 iterations. In all the simulations, the number and severity of catastrophes were kept constant along with all demographic parameters and the initial population size of 6 animals (2 females age 2, 2 females age 3 and 2 males age 4). This population was determined by an analysis of cheetah reproduction and a trial and error modeling for the most successful and economical initial population composition given the current Indian scenario.

The catastrophe was labeled disease with the frequency of occurrence of 5 years. The severity on reproduction and survival was taken as 0.5, because this was the maximum severity of many diseases.

Simulation 1- Supplementation of two individuals (1 male and 1 female) every 10 years, with harvest kept constant at 2 animals, every 5 years for the entire length of the simulation.

Simulation 2- No supplementation, with harvest kept constant at 2 animals, every 5 years for the entire length of the simulation.

Simulation 3- Harvest of 4 animals (2 males and 2 females), with supplementation kept constant at 2 animals (1 male and 1 female) every 5 years for the entire length of the simulation.

Simulation 4- Harvest of 6 animals (3 males and 3 females), with supplementation kept constant at 2 animals (1 male and 1 female) every 5 years for the entire length of the simulation.

Simulation 5- Supplementation of 2 animals (1 male and 1 female) every 5 years for the entire length of the simulation and a harvest of 2 animals, every 5 years for the entire length of the simulation.

The harvest was finally chosen at 2 animals (1 male and 1 female) every 5 years after reviewing the management structure of the study area along with the number of human settlements and the attitudes and diet of the local people.

Results

Density

The maximum densities in Kuno were of feral cattle. Chital distribution was patchy and had a high coefficient of variation. Cheetah prey includes chital, chinkara, calves of feral cattle and calves of nilgai.

The cattle calves made up 5% of the total feral cattle population. This is an age class that would constitute cheetah prey.

PHVA results of the study area

The survival rates of the population for the next 100 years was within the acceptable probability of greater than 0.95 for scenario 5, where the probability of survival was 0.99. Scenarios 1-4 did not show an acceptable probability of survival (0.81, 0.30, 0.93 and 0.89 respectively).

Discussion of the results of line transect sampling

The percentage of young was the highest among nilgai and the lowest among cattle during the sampling season. Chital and nilgai had a larger percentage of females than males in the population, indicating that males have a higher mortality rate than females (Caughley, 1966).

The average group sizes of chital and cattle were 5 and 11.13, with standard deviations of 2.50 and 2.99 respectively, while the average group sizes of chinkara and nilgai were 2.27 and 2, with standard deviations of 0.4 and 0.45 respectively. This shows that chital and cattle gather in larger groups than chinkara and nilgai. A reason for this could be that since chital and cattle are grazers whose food source is plentiful and chinkara and nilgai are browsers, the competition for specific foods is directly proportional to group sizes (Jarman, 1974). However, to counter this, larger group sizes are effective barriers against predation as there is a smaller probability of predation per animal with more individuals scanning for predators. Thus, a balance must be maintained between feeding and anti-predatory behavior, accounting for the varying group sizes.

Recommendations

All the prey in the grassland ecosystem encompassing the Kuno WLS are either wild or feral cattle and 1,280 km^2 of the total 3,000 km^2 ecosystem is protected, with no villages inside the core and buffer area of the wildlife sanctuary (Choudhary, 2001), thus providing favorable conditions for cheetah reintroduction and its long term survival. This is shown by a high probability of survival of the cheetah.

The best chance of survival of the cheetahs is in the Kuno ecosystem and they should be introduced there. The initial population size of the cheetahs should be a minimum of 6 animals with the age structure as follows: 2 females aged 2; 2 females aged 3; and 2 males aged 4. Females must be of different ages because there must be a variation in breeding cycles so as to ensure maximum survivability.

Supplementation should be a minimum of 2 animals (one adult male and one adult female) every five years, as this is the minimum viable population that can sustain the population. If the supplementation is decreased to two individuals every 10 years, then the probability of extinction increases from 0.01 to 0.19. Also, when there is no supplementation the probability of extinction further increases to 0.70.

Harvesting, in the form of cheetahs poached, can reach a maximum of two animals every 5 years; thus, heavy protection against poaching is required. Beyond this point, the probability of extinction increases greatly. If the harvest is increased to 4 animals every 5 years, then the probability of extinction increases from 0.01 to 0.06. When the harvest increases to 6 animals every 5 years, the probability of extinction further increases to 0.13.

Though there are no villages in the protected area (Banerjee, 2005), there are villages in the rest of the ecosystem and a compensation system should be established for livestock because there is a possibility of livestock predation despite the reasonable density of wild prey.

The carrying capacity of the ecosystem is 91 animals, and at this point some cheetahs should be relocated from this population so as to lower the chances of this population suffering an epidemic disease, to prevent inbreeding, and to help establish other populations.

No other large predator should be introduced at the same time as the cheetah population as the rate of cheetah mortality is likely to increase. This is evident in the Serengeti ecosystem, where lions account for a large portion of cheetah cub mortality (78.6% of all predation deaths) (Caro, 1994).

Acknowledgements

This research was done as part of the author's internship with the Wildlife Institute of India under the supervision of Y.V. Jhala. The author would like to thank Y.V. Jhala, Qamar Qureshi Chittranjan Dave, Faiyaz Khudsar and Rishi Kumar Sharma for all their help, support and inputs throughout the duration of this project, the he is grateful to the Director and Dean of the Wildlife Institute of India for his support.

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Table 1: Ecological densities of prey in the core area of Kuno Wildlife Sanctuary in winter 2006, as estimated by road transects.

	Density		Group Density		Encounter rate		ESW		CV% density
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	
Chital	12.761	12.039	2.5523	2.0423	0.28640	0.21945	56.106	12.934	94.34
Chinkara	10.062	3.1527	4.8577	1.2503	0.33413	0.47326E-01	34.392	7.3908	31.33
Cattle	95.843	118.10	7.0129	8.4673	0.28640	0.33904	20.419	4.8503	2.6135
Cheetah Prey	32.743	20.336	10.488	5.9931			46.650	5.7101	62.11
All Prey	76.022	49.643	14.639	9.0869	1.3604	0.82885	46.463	5.5103	65.30

*The half-normal key model was used estimate density (Laake, 1992).